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## The Evaluation Significance of Patents Cited by Humanities and Social Sciences Papers from the Perspective of Philosophy of Technology

Rui Li, Yang Gou, Zhibo Zhuang, Yu Gu

**Abstract:** The international authoritative patent intelligence firm CHI incorporated the "citations" between patents and scientific papers into the patent measurement indicator system, which has been widely used for over two decades. However, the phenomenon of patents being cited by humanities and social sciences papers has rarely been studied. This paper is based on two opposing theories within the philosophy of technology: the technological critique theory of the traditional pessimistic humanistic faction and the actor-network theory of the modern social construction faction, and proposes two contrary hypotheses: The first hypothesis assumes that the attitude of the humanities and social sciences toward technological inventions is one of concern and critique, thus hypothesizing that the vitality of patents is negatively correlated with the frequency of their citation (critique) by humanities and social sciences papers; The second hypothesis assumes that the relationship between the humanities and technological inventions is one of dialogue, negotiation, and mutual construction, thus hypothesizing that the vitality of patents is positively correlated with the number of humanities disciplines citing them (dimensions of dialogue and negotiation) and

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with the betweenness centrality in the 2-mode network (importance in social construction). Through an empirical study of global patents cited by A&HCI and SSCI journal papers, the first hypothesis is refuted, and the second hypothesis is validated, indicating that the current attitude of the humanities and social sciences toward technological inventions is not one of concern and critique, but rather one of dialogue and negotiation. Furthermore, the richer the dimensions of negotiation and mutual construction, the stronger the vitality of patents. Additionally, the more important the position of technological inventions in the social relational structure, the greater their vitality. It is suggested that the patent intelligence community pay attention to the phenomenon of patents being cited by humanities and social sciences papers. By measuring the "disciplinary richness" of the citing side and analyzing the structural characteristics of the two-mode citation network, the more comprehensive evaluation and foresight of patent vitality can be provided.

**Keywords:** Philosophy of Technology; Citation Analysis; Patent Metrics; Innovation Evaluation

**Author Biographies:** **Rui Li**, Ph.D., Professor, Ph.D. supervisor; primary research areas: scientometrics, information metrics, and evaluation; E-mail: [li\\_rui@scu.edu.cn](mailto:li_rui@scu.edu.cn); **Yang Gou**, Ph.D. candidate; primary research areas: information analysis and metrics; E-mail: [2433074414@qq.com](mailto:2433074414@qq.com); **Zhibo Zhuang**, Ph.D. candidate; primary research areas: digital humanities and information metrics; E-mail: [zhizhuan@iu.edu](mailto:zhizhuan@iu.edu). **Yu Gu (translator)**, Ph.D., currently at Yangzhou Vocational and Technical University. E-mail: [1187380473@qq.com](mailto:1187380473@qq.com).

## 0.Introduction

In 2000, CHI (Computer Horizon Incorporation) (2000), a leading international patent intelligence agency, established a patent metrics system, several of whose indicators are derived from statistics on citation frequencies between patents and scientific papers. Over the past two decades, among the journal articles indexed in WOS, 224 focused on "patents citing scientific papers," while 9 focused on "patents cited by scientific papers"; among the Chinese journal articles indexed in CNKI, 23 focused on "patents citing scientific papers," while 4 focused on "patents cited by scientific papers." The aforementioned studies have largely focused on the "linkage between technology and science." Most of the findings analyze the scientific foundations underpinning technological innovation, with representative works including (Hinze S, 2004; Halevi G, 2012; Hancheng Cao, 2023; Shuo Xu, 2024; Ascione G S, 2024), others evaluate patents by assessing the strength of their scientific foundations, with representative works including (Harhoff D, 2016; Van Raan A F J, 2017; Mariani M S, 2019; Gema Velayos-Ortega, 2023)

Few scholars have conducted specialized research on the citation relationship between patents and papers in the humanities and social sciences. Currently, the only relevant study found is the article "The citation impact of social sciences and humanities upon patentable technology," published in

*Scientometric* (Moya-Anegon F D, 2020). This paper analyzed approximately 876,000 Scopus-indexed articles from humanities and social sciences journals cited in European and American patents between 2008 and 2017, and compiled data on how invention patents from companies such as IBM, Oracle, Microsoft, and Samsung cited articles in history, art, psychology, philosophy, and education. For example, a patent for a "music player" cited a psychology paper titled "The Relationship Between Music Performance and Auditory Behavior and Personality Traits" to demonstrate the "adaptability" of music playback technology to social needs in the psychological dimension. Beyond this, no other scholars have investigated the phenomenon of "patents being cited by humanities and social sciences papers," and the evaluative significance inherent in such citations has not been thoroughly explored.

## **1. Theoretical Foundations of the Philosophy of Technology**

The relationship between technology and the humanities and social sciences is a fundamental and central issue in the philosophy of technology. For a long time, the philosophical community has been divided between those who view technology as inherently evil and those who see it as inherently good; philosophers' attitudes have shifted from pessimistic concern to optimistic construction, and from critical resistance to inclusive acceptance.

### **1.1 The Traditional Humanist School's Pessimistic Theory of Technological Autonomy**

For a long time, the philosophical community has harbored deep concerns about "technology." Rousseau (2016) not only worried about the destruction of nature caused by technology but also emphasized that technological progress exacerbates the alienation of human nature and social relations while undermining human moral judgment. Heidegger's "theory of the coercion of technology" (Heidegger, 2018) and Marcuse's "one-dimensional man" (Marcuse, 2014) both point to the underlying logic of technology—that it invisibly confines people within a predetermined technological framework, where true freedom and liberation are obscured by false choices. Ellul (1964) went so far as to state bluntly: "From the perspective of technology, man is a useless appendage." Following the Second Industrial Revolution, Anders (2010) delved into the laws governing the autonomous development of technology, highlighting its inherent autonomy and uncontrollability. The theory of technological autonomy flourished in the 1950s - 1970s; Winner's *Autonomous Technology: Uncontrolled Technology as a Theme in Political Thought* argued that technology would evolve into an uncontrolled, destructive, and alienating force, posing a fundamental threat to all of human society (Winner, 2021)

As a pessimistic tendency, the doctrine of technological autonomy is rooted in a sense of foreboding at the subconscious level; as a rational construct, it represents a negative mode of thinking; and as a social trend, it is an external manifestation of the intense conflict inherent in technology (Zhao Jianjun, 2004). The philosophical community has labeled this school of technological philosophy as

the "humanist school," for reasons articulated by Snow (Snow, 1994): "The technopessimistic attitudes of the humanities and dystopian literature are often associated with the ideals of pre-industrial society and exhibit a self-centered tendency." The Humanist School emphasizes the intrinsic logic and autonomy of technological development and adopts a critical stance toward technology; the technological landscape viewed through its lens is one of pessimistic, unqualified negation—"recognizing the conflict between humanity and technology, and convinced that technology threatens human freedom."

### 1.2 The Actor-Network Theory of Modern Social Constructionism

The social constructionist school of philosophy of technology originated with the 1987 book *The Social Construction of Technological Systems*, edited by Pinker, Bick, and Hughes. The numerous practical case studies in the book demonstrate that technology is constructed by various social factors, and that technology and its formation are closely linked to historical, economic, political, psychological, and social factors (Sheng Guorong, 2011). In 1998, Schurman (1995) further emphasized the "empirical turn" in the philosophy of technology: any new technology is not only internally linked to specific subsystems of numerous related fields, but also, from an external perspective, involves various social dimensions such as politics, culture, and economics; Fundamentally, the emergence of an invention is not driven by the traditional pursuit of efficiency in technology, nor is the improvement of inefficient technologies merely a catalyst; rather, the decisive factors are the social forces operating across various related dimensions. Social constructivists point out that traditional humanists "pay no attention whatsoever to the living, concrete technological phenomena in real society, much less enter laboratories to understand the true nature and reality of a given technology"(Carl Mitcham, 1999), "interpret the meaning of technology from non-technical or supra-technical perspectives," and "technology is always explored as a vague, abstract, and unchanging whole, as if it were a sealed black box, and humanists make no attempt to open this black box" (Gu Shichun,2024).

Social constructivists advocate using sociological methods to examine the role of social, institutional, economic, and cultural forces in the formation of technology. They delve into relevant social factors to conduct a detailed analysis of specific technological practices, thereby truly opening the "black box" of technology. From the perspective of social constructivists, the relationship between technology and society is not one of unidirectional determination and being determined, but rather one of mutual interpenetration, forming a "seamless network" of what is termed a "socio-technical complex" (Sheng Guorong,2011). In their book *The Sociology of Actor-Networks: The Case of the Electric Car*, Latour and Callon systematically elucidate how social factors construct and shape technology: a French electronics company proposed a plan to develop a new type of electric vehicle; this plan required another company to develop the battery engine and second-generation batteries, and also required Renault to be responsible for assembling the chassis and manufacturing the body,

Furthermore, social and even non-social factors—such as consumers, government agencies, and lead-acid batteries—must be taken into account. These factors are all "actors" that together constitute an interdependent networked world (Zheng Xiaosong, 2017). At the beginning of this century, Latour proposed the theory of actor-network theory, whose three core concepts are: actor, translation, and network. "Actor" is a concept at the level of practice, encompassing not only the people who carry out a particular action but also related non-material elements such as rules, organizations, and values (Cheng Sumei., 2006). Each specific actor possesses distinct values, behavioral traits, and interests, and is constantly embedded within a network of relationships; "Translation," acting as a mediating force, implies that within the entire network of actors, each actor, grounded in their own values and interests, interprets the intentions of other actors through their own modes of expression. Consequently, different actors interact through mutual translation, are brought together, and, following the principle of "following the actor," continuously construct and shape the entire network; "Network" emphasizes wholeness and relationality: technological activity is essentially a dynamic network system formed by the interconnection and mutual construction of diverse actors. Technology is not a knowledge system with an independent logical framework; it has become intertwined with and integrated into society.

## **2. Research hypotheses**

One effective approach to concretizing abstract concepts is to apply a conjugate transformation to them. From the perspective of such a transformation, this paper treats patents as representatives of technological innovation in society and uses the phenomenon of patents being cited in humanities and social sciences papers to map the attitudes of the humanities and social sciences toward technological innovation (whether negative or positive). Based on the theoretical foundation outlined in Section 1, "Theoretical Foundations of the Philosophy of Technology," the following hypothesis is proposed:

### **2.1 Hypothesis 1: Based on the Pessimistic Theory of Technological Autonomy in Traditional Humanism**

Based on the pessimistic theory of technological autonomy in traditional humanism, the motivation behind humanities and social science scholars' "citation" of patents should be to reflect on technological innovation, to evaluate, assess, regulate, and adjust technological inventions, and to examine and critique the value of technological innovation from the perspective of human nature. Since the theory of technological autonomy represents a negative mode of thinking, the "citation" of patents in humanities and social science papers expresses societal concerns, resistance, or criticism toward technological innovation, reflecting the negative value effects of innovation. In summary, we propose H1:

H1: The vitality of patents (technological innovation) is negatively correlated with the frequency of their citation in humanities and social science papers (the extent to which they are criticized by the

humanities and social sciences).

## 2.2 Hypothesis 2, based on the social constructionist theory of actor-network theory

In line with the 'turn to experience' emphasised by social constructionism, technological inventions are shaped by social forces across various dimensions (aesthetics, interests, beliefs, etc.). Technological innovation represents an 'adaptive' response to these diverse social forces, emerging through negotiation; thus, its formation is not merely the result of the labour of engineers and inventors, but also embodies the collective wisdom of relevant social stakeholders across multiple dimensions. Consequently, the citation of technological innovations (patented inventions) in humanities and social science papers across various disciplines reflects the 'negotiation' between technological innovation and social forces across multiple dimensions. Through 'citation', scholars in the humanities and social sciences engage in a multidimensional intellectual dialogue with technological innovation, encompassing political, economic, cultural and value-based dimensions. In summary, Hypotheses H2 and H2a are proposed:

H2: The vitality of a patent (technological innovation) is positively correlated with the frequency of its citation in humanities and social science papers (the degree of social negotiation).

H2a: The vitality of a patent (technological innovation) is positively correlated with the number of disciplines represented by the citing humanities and social science papers (the dimensions of negotiation and adaptation).

Next, drawing on actor-network theory, technical actors achieve negotiation and adaptation through mutual translation; their interactions and combinations form a holistic network. This breaks down the 'subject-object' dualism of traditional philosophy of technology—characterised by 'abstract subjects' and 'absolute technology'—with actor-network theory employing relational and structural thinking to understand technology in contemporary society. In summary, we propose Hypothesis H2b:

H2b: The vitality of patents (technological innovation) is positively correlated with their intermediary centrality (importance within the social structural framework) in the citation network.

## 3. Hypothesis Testing

### 3.1 Testing Methods

#### 3.1.1 Bivariate Correlation Analysis

Bivariate correlation analysis provides a quantitative basis for understanding the mutual influence between variables by assessing the linear relationship between two variables and its strength. Commonly used bivariate correlation analyses and coefficients for non-normally distributed data include the following two: ① The Kendall correlation coefficient is used to measure the rank correlation between two variables. A common formula is Kendall's Tau<sub>b</sub>:

$$T_b = \frac{C - D}{\sqrt{(C + D + T)(C + D + U)}}, \text{ among which } C \text{ is the number of pairs in the correct order, } D \text{ is}$$

the number of pairs in the reverse order,  $T$  is the number of pairs at the same level within the ordinal

scale of  $X$  variable, and  $U$  is the number of pairs at the same level within the ordinal scale of  $Y$  variable; ② The Spearman correlation coefficient is used to assess the monotonic trend between two variables and is typically applied to non-parametric data. It is calculated as:  $p = 1 - \frac{6 \sum d_i^2}{n(n^2 - 1)}$ , where  $d_i$  is the difference in ordinal levels between the two variables, and  $n$  is the sample size.

### 3.1.2 Survival Analysis

Survival analysis is a statistical method that reveals the patterns of dynamic processes by analysing the distribution of event occurrence times and their influencing factors. Key elements include the starting event, the endpoint event, survival outcomes ('death' and 'censoring'), and survival time. The Kaplan-Meier method in survival analysis is a non-parametric test that accommodates complete, censored and truncated data. It utilises the product-rule theorem to calculate survival rates and employs the Log-rank test to compare differences in survival rates between groups; it is suitable for analysing the impact of a single risk factor on survival time. The formula for calculating the cumulative survival rate is  $S(t) = \prod_{i=1}^k (1 - \frac{d_i}{n_i})$ . In the equation,  $d_i$  represents the number of individuals for whom an event occurs at time  $t$ , and  $n_i$  represents the total number of individuals in the risk population at time  $t$ .

### 3.1.3 Social Network Analysis

Social network analysis is a research method that explores the networks of relationships between individuals or organisations to reveal their patterns of interaction and network structures. A 2-modular network is a specific structure within social networks: a topological structure comprising two types of nodes. Betweenness centrality reflects the proportion of the shortest path between any two nodes that a given node occupies within a 2-modular network. Nodes with high betweenness centrality connect different sub-groups or modules, acting as information hubs and relational links. The formula is as follows:  $C_B(v_i) = \sum_{s \neq v_i, \neq t} \frac{\sigma_{st}(v_i)}{\sigma_{st}}$ ,  $\sigma_{st}$  represents the total number of shortest paths from node  $s$  to node  $t$ , and  $\sigma_{st}(v_i)$  represents the number of paths from node  $s$  to node  $t$  that pass through node  $v_i$ .

## 3.2 Sample Data

This paper conducted a preliminary survey on the citation patterns of patents in humanities and social sciences journals. The results indicate that the frequency with which US patents are cited in such journals is approximately 20 times that of Chinese patents, over 80 times that of South Korean patents, over 200 times that of Japanese patents, and nearly 300 times that of German patents... To ensure an adequate sample size, this paper selected US patents as the subject of the empirical study. In the Web of Science Core Collection, the Social Sciences Citation Index (SSCI) and Arts & Humanities Citation

Index (A&HCI) databases were selected. Then, by clicking 'Cited References' and 'Cited Works' in sequence, and entering 'US Patent' in the search box that appeared, 2,083 patents cited by humanities and social sciences papers were identified.

However, the patents retrieved in the aforementioned search lacked details such as patent numbers, IPC classifications and expiry dates; moreover, the limited information available—such as application dates, patent titles and patent holders—contained errors. Consequently, this study drew upon the limited data mentioned above and began by searching for the patent number associated with each patent in the US Patent and Trademark Office's (USPTO) Patent Publication Search Basic (PPUBS Basic) platform. Furthermore, using the patent numbers, the corresponding application dates, expiry dates and IPC classification codes for each patent were supplemented or verified within the PatSnap patent database. Following data cleansing, 1,234 patents with complete information were ultimately obtained from the original 2,083 patents, along with 3,730 citing humanities and social sciences papers.

Table 1 presents basic statistical data on the disciplines of the citing humanities and social sciences papers and the fields of the cited patents. The data shows that the citing papers originate from a wide range of humanities and social science disciplines: papers in the field of Economics and Management accounted for the largest proportion (21.85%), followed by Politics, Law and Military Affairs (21.37%) and Social and Psychological Sciences (17.24%). On the cited patent side, patents in the physics category accounted for the largest proportion (41.17%), followed by the category of essential goods for human life (22.04%) and the category of chemistry and metallurgy (12.88%).

Citing discipline	Paper citing patent		Cited patent field	Patent cited by paper	
	N	%		N	%
Arts and Culture	335	8.98%	Essentials for human life	272	22.04%
Economics and Management	815	21.85%	Construction and transport	122	9.89%
History and Archaeology	386	10.35%	Chemistry and metallurgy	159	12.88%
Literature and Languages	77	2.06%	Textiles and paper	14	1.13%
Philosophy and Religion	60	1.61%	Buildings	44	3.57%
Communication and Information Sciences	617	16.54%	Mechanical engineering	20	1.62%
Social and Psychological Sciences	643	17.24%	Physics	508	41.17%
Politics, Law and Military Studies	797	21.37%	Electrical engineering	95	7.70%
Total	3730	100%	Total	1234	100%

Table 1: Statistical data on the disciplines of citing papers and the fields of cited patents

Through a close, case-by-case examination of the citing papers, we found that the article 'In the Blink of an Eye, They Disappeared: Public Relations and the Battle for Attention', published in the Journal of Public Relations, cited US Patent No. 6053739, 'Measurement of Attention Span and

Attention Deficit', to illustrate how this technology serves the societal need for attention measurement; the article "A Discussion on Patentometrics in the Field of Digital Humanities", published in Library Trends, cites US Patent No. 3050870, "Sensory Simulator", to illustrate how this technology serves the societal need for the digitisation of humanities resources; the article "Should We Contact Our Neighbours? Voluntary Review and Citizen Complaints Regarding Oil and Gas Drilling", cited US Patent No. 4482459, "Continuous Process for the Recovery of Waste Drilling Fluids", to illustrate how this technology serves the environmental protection needs of energy development... Table 2 lists some other examples.

Journal Title	Title of Cited Article	Title of Cited Patent	The relationship between the technology described and the humanities and social sciences
LIBRARY TRENDS	Stuffing, Sniffing, Squatting, and Stalking: Sham Activities in Affiliate Marketing	Validating Internet Ad Conversions	Patented technology addresses the societal need to 'detect fraudulent activity'
HISTORY AND TECHNOLOGY	'Remember the Sabbath': a history of technological decisions and innovation in Orthodox Jewish communities	Electronic Appliance and a Sabbath Mode Therefor	Patented technology addresses the social need to 'observe the Sabbath'
COGNITIVE RESEARCH-PRINCIPLES AND IMPLICATIONS	The scent of attraction and the smell of success: crossmodal influences on person perception	Method of altering age perception	Patented technology addresses the social need to 'enhance appeal and an aura of success'
COGNITIVE RESEARCH-PRINCIPLES AND IMPLICATIONS	A three-factor benefits framework for understanding consumer preference for scented household products: psychological interactions and implications for future development	Freshening compositions having a malodor control component and methods thereof	Patented technology addresses the social need for 'preference for scented home products'
COMPUTER MUSIC JOURNAL	Expressive Robotic Guitars: Developments in Musical Robotics for Chordophones	Self-Tuning Tail Piece for String Instruments	Patented technology addresses the social need for 'robotic guitars'
COMPUTER MUSIC JOURNAL	Playing Music in Just Intonation: A Dynamically Adaptive Tuning Scheme	Method of and control system for automatically correcting a pitch of a musical instrument	Patented technology addresses the social need to 'perform music in just intonation'

JOURNAL OF CULTURAL HERITAGE	Visual information retrieval from historical document images	Method and apparatus for performing document structure analysis	Patented technology addresses the social need to 'extract information from historical images'
JOURNAL OF CULTURAL HERITAGE	Assessment of plasma torches as innovative tool for cleaning of historical stone materials	Atmospheric pressure method and apparatus for removal of organic matter with atomic and ionic oxygen	Patented technology addresses the social need for 'cleaning historic stonework'
ORGANISED SOUND	Materiality in Sound Art	Method and Apparatus for Recreating a Musical Performance	Patented technology addresses the social need for 'optimising sound art'
JOURNAL OF THE ASSOCIATION FOR INFORMATION SCIENCE AND TECHNOLOGY	Task Complexity and Difficulty in Music Information Retrieval	Music search by melody input	Patented technology addresses the social need for 'music retrieval'
JOURNAL OF THE ASSOCIATION FOR INFORMATION SCIENCE AND TECHNOLOGY	The Effect of Personalization Provider Characteristics on Privacy Attitudes and Behaviors: An Elaboration Likelihood Model Approach	System and method for providing client-side personalization of content of web pages and the like	Patented technology addresses the social need for 'web privacy protection'
JOURNAL OF RETAILING AND CONSUMER SERVICES	Business competitive analysis using promoted post detection on social media	Method of delivery, targeting, and measuring advertising over networks	Patented technology addresses the social need for 'detecting commercial competition on social media'

Table 2 Examples of Patents Cited in Humanities and Social Sciences Papers (Partial List)

### 3.3 Testing Procedure

This section tests the proposed hypotheses based on the research data and methods outlined above. The specific approach and steps are as follows: Firstly, Kaplan-Meier analysis is used to test whether the correlations mentioned in hypotheses H1 and H2 hold true. Furthermore, bivariate correlation

analysis is employed to confirm the identified correlations, thereby enhancing the reliability of the findings.

### 3.3.1 Testing Hypothesis 1

The study defined patent longevity as the 'survival event' and constructed a Kaplan-Meier survival analysis model based on the frequency of citations of humanities and social sciences papers. The model was calculated using SPSS 25.0 software. The results are as follows:

In Figure 1, the horizontal axis represents the duration of a patent's validity, i.e., its lifespan, whilst the vertical axis represents the cumulative survival rate, i.e., the proportion of patents that are still 'alive' at a given point in time out of the total number of patents. According to Figure 1 and Table 3, the four patent survival curves based on the frequency of citations in humanities and social sciences papers show marked differences in their vertical positions: the proportion of lost data for highly cited patents is 73.8%, for moderately cited patents it is 68.2%, for less frequently cited patents it is 55.9%, and for low-cited patents it is 52.1%. Furthermore, the p-value of the Log-Rank test was 0.000 at a significance level of 0.01, indicating that there is a statistically significant difference between the four survival curves.

The four categories—high, relatively high, relatively low and low citation frequency—are classified using the quartile method. This involves arranging the data on the frequency with which patents are cited in humanities and social sciences papers from the maximum (Max) to the minimum (Min). Q2 is the median (Median) between the two; at Q2, the sequence is divided into two regions. Q1 is the median of the first region, Q3 is the median of the second region. The region from the maximum value (Max) to Q1 is defined as the high-citation frequency region; the region from Q1 to Q2 is defined as the relatively high-citation frequency region; the region from Q2 to Q3 is defined as the relatively low-citation frequency region; and the region from Q3 to the minimum value (Min) is defined as the low-citation frequency region.

Name	Category	Total N	Censored	
			N	Percent
Number of citations	Low citation frequency	838	437	52.1%
	Moderate citation frequency	145	81	55.9%
	High citation frequency	148	101	68.2%
	Very high citation frequency	103	76	73.8%

Table 3: Results of Kaplan-Meier analysis based on citation frequency of humanities and social sciences papers

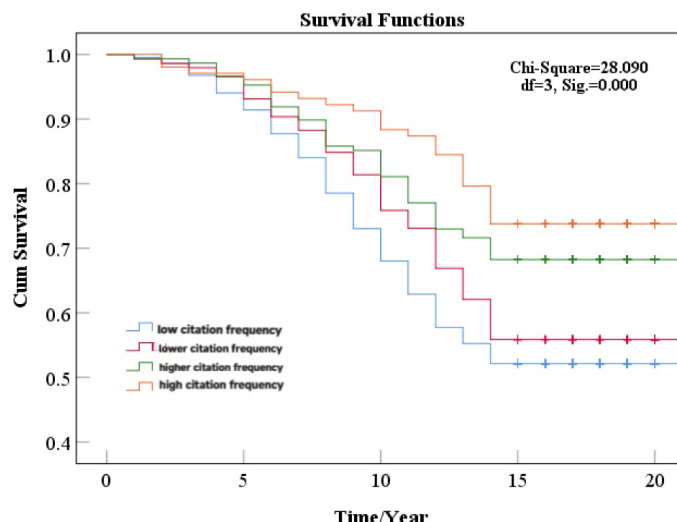


Figure 1: Estimation of patent survival curves based on the frequency of citations from humanities and social sciences papers

Next, we used bivariate correlation analysis to verify the conclusions drawn from the survival analysis. The results of the Kendall and Spearman correlation coefficients (Table 4) both indicate that patent longevity is positively correlated with the frequency of citations from humanities and social sciences papers. Therefore, the null hypothesis H1 is rejected.

	Patent longevity	Citation frequency
Kendall Correlation	1.000	0.127
Sig.		0.000
Spearman Correlation	1.000	0.160
Sig.		0.000

Table 4: Results of bivariate correlation analysis

### 3.3.2 Testing Hypothesis 2

The conclusion of the analysis in Section 3.3.1 is that patent longevity is positively correlated with the frequency of citations from humanities and social sciences papers, thereby confirming H2.

Furthermore, taking patent longevity as the 'survival event', we constructed a Kaplan-Meier survival analysis model based on the number of citing disciplines in humanities and social sciences papers, and performed the model calculations using SPSS 25.0 software. The results are as follows:

Figure 2 shows that the survival curves for patents based on the number of disciplines in the citing humanities and social sciences papers differ significantly in their vertical positions. Specifically, the proportion of missing data for patents with a high number of citing disciplines was 87.1%, for those with a relatively high number of citing disciplines it was 67.9%, and for those with a relatively low number of citing disciplines it was 64.7%. whilst patents associated with a low number of cited humanities and social sciences papers accounted for 52.9% of the loss data (Table 5). Furthermore, the p-value of the Log-Rank test was 0.000 at the 0.01 significance level. This indicates that there are statistically significant differences between the survival functions of the four groups.

Name	Category	Total N	Censored	
			N	Percent
Number of disciplines with low citation counts	Number of disciplines with very low citation counts	949	50	5.2%
	Number of disciplines with moderate citation counts	201	13	6.4%
	Number of disciplines with high citation counts	53	36	67.9%
	Number of disciplines with very high citation counts	31	27	87.1%

Table 5 Results of the Kaplan-Meier analysis based on the number of cited humanities and social sciences papers

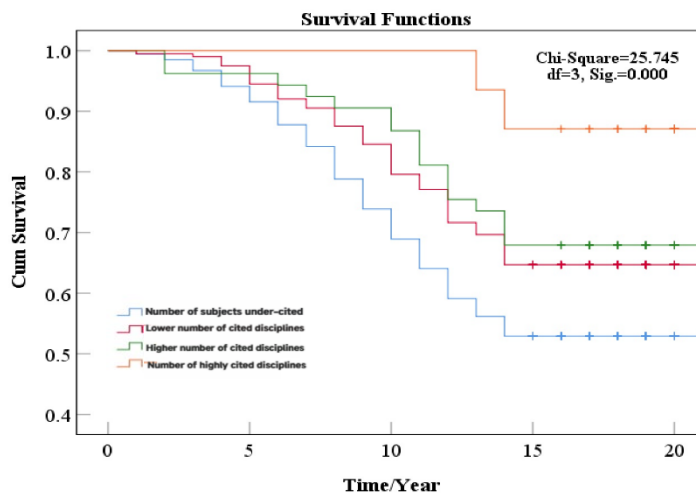


Figure 2: Estimation of the patent survival function based on the number of citing humanities and social sciences papers

Next, we used bivariate correlation analysis to verify the conclusions drawn from the survival analysis. The results of the Kendall and Spearman correlation coefficients (Table 6) both indicate that patent longevity is positively correlated with the number of citing humanities and social sciences papers. Therefore, the null hypothesis H2a is accepted.

	Patent Longevity	Number of Citing Disciplines
Kendall Correlation	1.000	0.129
Sig.		0.000
Spearman Correlation	1.000	0.156
Sig.		0.000

Table 6: Results of bivariate correlation analysis

The 2-Model Network Analysis Tool provides a means of simultaneously analyzing the disciplinary associations of cited humanities and social sciences papers and the IPC classification associations of cited patents. In accordance with the International Patent Classification (IPC) technical field (Class) classification standards, 1,234 patents were categorized into 61 technical fields, whilst 3,730 citing humanities and social sciences papers were categorized into 46 disciplines based on the subject classifications (Categories) in Web of Science (WOS). A matrix of cited patent fields × citing paper disciplines was constructed, and the data was then imported into Gephi software to generate and



high mediating centrality was 66.7%, the proportion in fields with lower mediating centrality was 61.5%, and the proportion in fields with low mediating centrality was 25.0% (Table 7). Furthermore, the p-value from the Log-Rank test was statistically significant at the 0.01 level (Sig < 0.01). That is, there are statistically significant differences among the four groups' survival curves.

Name	Category	Total	Censored	
		N	N	Percent
Citation 2 - Intermediary centrality in network models	Low intermediary centrality	16	4	25.0%
	Moderately low intermediary centrality	13	8	61.5%
	Moderately high intermediary centrality	18	12	66.7%
	High intermediary centrality	14	11	78.6%

Table 7 Results of Kaplan-Meier analysis based on high and low centrality in the Citation 2-model network

The four categories—high centrality, relatively high centrality, relatively low centrality and low centrality—are classified using the quartile method. This involves arranging the centrality values of patent end nodes in the cited 2-modular network from the maximum (Max) to the minimum (Min). Q2 is the median (Median) between these two values; at Q2, the sequence is divided into two regions. Q1 is the median of the first region, Q3 is the median of the second region. The region between the maximum value (Max) and Q1 is defined as the high inter-centrality region; the region between Q1 and Q2 is defined as the relatively high inter-centrality region; the region between Q2 and Q3 is defined as the relatively low inter-centrality region; and the region between Q3 and the minimum value (Min) is defined as the low inter-centrality region.

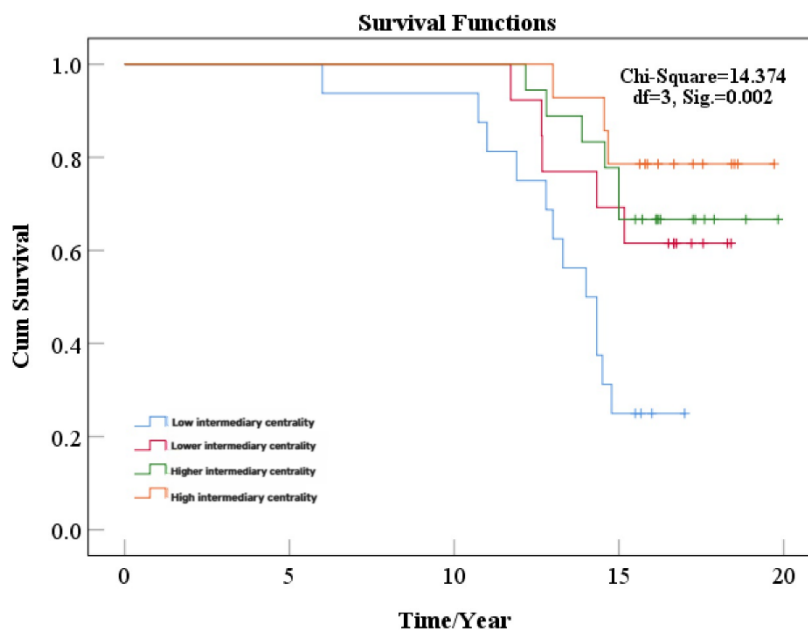


Figure 4: Estimation of survival functions for patents within a technical field based on high and low mediating centrality

Next, the Kendall and Spearman coefficients were employed to verify the relationship between the average lifespan of patents within the technical field and their betweenness centrality in the citation 2-modal network. The results (Table 8) indicate that the average lifespan of patents within the technical field is positively correlated with their betweenness centrality in the citation 2-modal network. Therefore, the null hypothesis H2b is accepted.

	Patent Longevity	Intermediary Centrality
Kendall Correlation	1.000	0.241
Sig.		0.008
Spearman Correlation	1.000	0.338
Sig.		0.008

Table 8 Results of bivariate correlation analysis

In summary, patent longevity is positively correlated with the frequency of citations in humanities and social sciences papers; Hypothesis 1 is thus rejected. Patent longevity is positively correlated with the number of citing disciplines, and it is positively correlated with the betweenness centrality in the citation network; Hypothesis 2 is therefore confirmed.

#### 4. Research Conclusions

As discussed in the section '3. Hypothesis Testing' above, Hypothesis 1 (H1) has been rejected, whilst Hypotheses 2 (H2, H2a and H2b) have been confirmed.

The rejection of H1 indicates that there is no negative correlation between the longevity of a patent and the frequency with which it is cited in humanities and social sciences papers. This suggests that the contemporary humanities and social sciences do not adopt an attitude of resistance or criticism towards technological inventions. The argument put forward by traditional humanist philosophers of technology—that technological development is autonomous and uncontrollable and should therefore be resisted and criticized—is not prevalent in contemporary humanities and social sciences.

H2a is confirmed, namely that patent vitality is positively correlated with the number of humanities disciplines citing the patent (the social construction dimension); in the sample data, the citing humanities and social science papers are distributed across disciplines such as politics, economics, art, history and education. Citations of patents by papers from multiple disciplines reflect: the negotiation between social forces across multiple dimensions and technological inventions, as well as the construction of technological inventions by social wisdom across multiple dimensions; The greater the diversity of dimensions in which a patent demonstrates its adaptability to society, the stronger its vitality becomes.

H2b has been confirmed, namely that patent vitality is positively correlated with the intermediary centrality (structural importance within the actor network) in the 2-mode network; This indicates that technology is not isolated; the 'actors' of technological invention form a 'network' with various

constructive forces in the humanities and social sciences through the mediating role of 'translation'. Under the principle of 'following the actor', the more a patent occupies a key mediating structural position, the greater its influence and adaptability towards the various social forces within the entire network, and the stronger its vitality.

In summary, the findings of this empirical study indicate that the current attitude of the humanities and social sciences towards technological inventions is one of dialogue and consultation rather than concern and criticism; furthermore, the greater the diversity of dimensions in the dialogue between technological inventions (patents) and the humanities and social sciences (as indicated by the number of disciplines citing them), the greater their vitality; and the more central a technological invention (patent) is within the structure of social relations (as indicated by higher intermediary centrality in the citation network), the greater its vitality.

## **5. Summary and Recommendations**

Regarding the relationship between technology and human society, philosophers across the ages have expressed both disagreement and consensus: Fromm's (1988) theory of 'humanizing technological innovation' and Mumford's (2016) exposition of the 'life-oriented value of technology' both emphasize the social relevance of technology; In the view of Saint-Simon (Bazard, 2018), the root of social problems lies not in the autonomy of technology, but precisely in the fact that technology has not yet fully realized its potential; he advocated achieving orderly social functioning and equitable distribution through technological innovation and industrial management; Snow (He Jianqin, 2014), in *The Two Cultures*, expanded upon Saint-Simon's argument, proposing that: "In a balanced society, technological progress must be combined with the humanities—such as literature, history and philosophy—to bring about genuine social progress." Latour's (Cheng Sumei, 2006) theory of actor-network theory offers an even more comprehensive perspective: technology interacts with various actors within social networks to form complex synergistic relationships, evolving through interactions within social power structures and networks; the relationship between technological invention and social structure is one of mutual dependence and symbiosis.

The empirical findings of this paper corroborate the social constructionist theory of the philosophy of technology: patent vitality is positively correlated with the frequency of citations in humanities and social sciences papers, reflecting the 'negotiation and adaptation' between contemporary technological inventions and the humanities and social sciences; patent vitality is positively correlated with the disciplinary diversity of the citing humanities and social sciences papers, reflecting how contemporary technological inventions are being 'shaped' by the multidimensional forces of the humanities and social sciences; Patent vitality is positively correlated with the betweenness centrality of the citation network, reflecting how contemporary technological inventions are being 'constructed' by the structure of the

social networks in which they are embedded. Consequently, the frequency with which a patent is cited in humanities and social sciences papers, the disciplinary diversity of the citing papers, and the betweenness centrality of the patent within the citation network all hold positive evaluative significance. In summary, it is recommended that the patent intelligence community pay attention to the phenomenon of patents being cited by humanities and social sciences papers, and incorporate indicators such as the frequency of such citations, the disciplinary diversity of the citing papers, and the patent's betweenness centrality within the citation network into the scope of patent metrics, thereby providing a broader basis for a more comprehensive evaluation of patents.

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## ORCID

Gu Yu<sup>ID</sup><https://orcid.org/0009-0000-2889-3013>

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